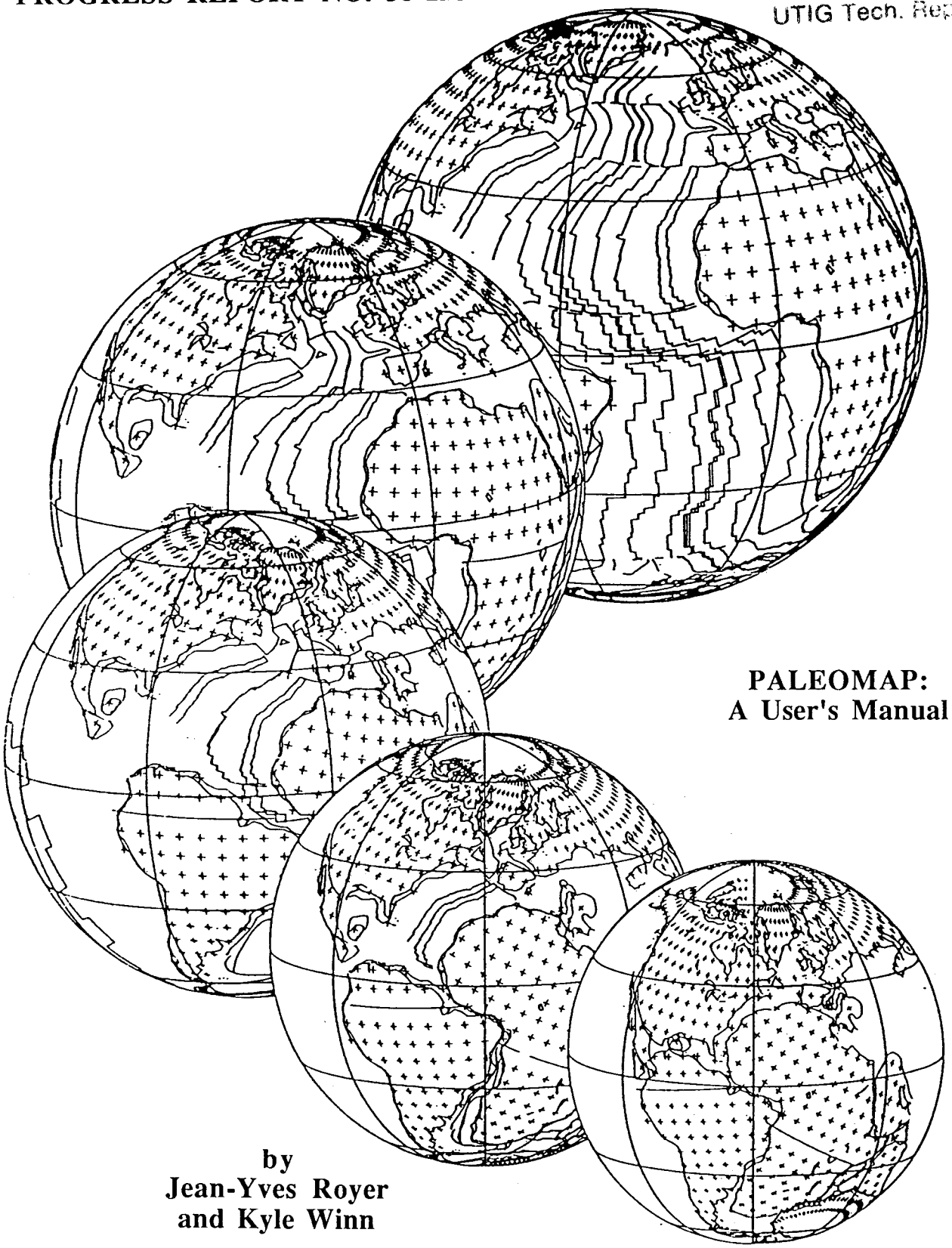
PALEOCEANOGRAPHIC MAPPING PROJECT
PROGRESS REPORT NO. 38-1287



PALEOMAP:
A User's Manual

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INTRODUCTION

PALEOMAP is a digital tectonic reconstruction program used to create paleocontinental base maps. It takes tectonic features in the form of digitized data files, assembles those features in accordance with user specified rotation criteria, and creates a plot file, which when plotted yields a map of size, projection, and format selected by the user.

The inputs the user needs to provide interactively are:

This manual explains the requirements or the options for each intput items. Information about the structures, codes and standard formats of the data files can be found in the User's Manuals concerning the digitizing software (POMP Report # 37-1287) and the data management software (POMP Report # 36-1287).

Examples:

This manual uses many figures (p. 12 to 18) to demonstrate the capabilities of PALEOMAP. Each figure is constructed using the same data file. The digitized features comprising this file are the coastlines of South America and Africa, the South Atlantic spreading ridge, and a set of South Atlantic isochrons. The isochrons are of anomaly ages 3, 9, 13, 18, 21, 24, 28, 34, and M0.

TIME OF RECONSTRUCTION

The time for which PALEOMAP asks is the intended time, in millions of years ago, of the reconstruction:

ENTER TIME (Ma) 999 & 998=special options

0 (time =) For a present-day map, no rotation file is needed, all tectonic elements will be plotted

999 (time =) This option allows the user to test a single rotation between two tectonic elements, to be given interactively following this message on the screen:

```
Enter one specific rotation between plate ID & and plate IDREF
ID,LAT,LON,ANG,IDREF,IRS (IRS=1 to add up another rotation) ??
802 34.5 28.9 -34.50 801 0                    (input)
```

In this example, the finite rotation tested is 34.5°N, 28.9°E (euler pole) and -34.50° (angle) between Antarctica (802) and Australia (801, here the reference plate). IRS is set to zero. When set to 1, it allows the concatenation of other rotations to the first rotation:

```
802 34.5 28.9 -34.50 801 1                    (if first input)
LAT,LON,ANG supp. (99 0 0 to end) ?
35.2 -18.4 32.56                              (input)
12.2 55.4 13.22                               (input)
99. 0. 0.                                     (input to end the list)
```

The program then calculates the sum of these 3 rotations. The resulting rotation concern the motions of Antarctica (802) relative to Australia (801). **Note that only the data related to these two tectonic elements will be plotted.**

998 (time =) This option allows the user to select the tectonic elements that will appear on the plot in their present day-position (i.e. time = 0):

```
Enter the tectonic elements that will appear on your plot (0=end)
     (in their present day position)
701                                           (input for Africa)
802                                           (input for Antarctica)
201                                           (input for South America)
0                                             (input to end the list)
```

Note that only the data related to these tectonic elements will be plotted.

any (time =) This is the standard input. The user is then asked for a rotation file:

```
Enter name of the rotation file ??
MASTER.ROT                                    (input)
```

After the time of reconstructions and subsequent inputs are provided, the number of tectonic elements considered is displayed:

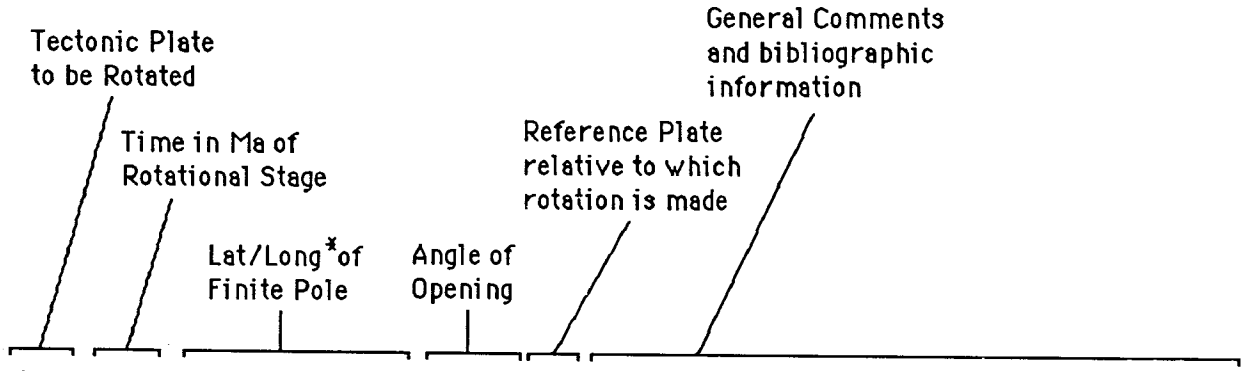
```
All plates are considered          (if time = 0)

# of plates in model = 2           (if time = 999)

# of plates in model = X           (if time = 998 or any)
```

ROTATION FILE

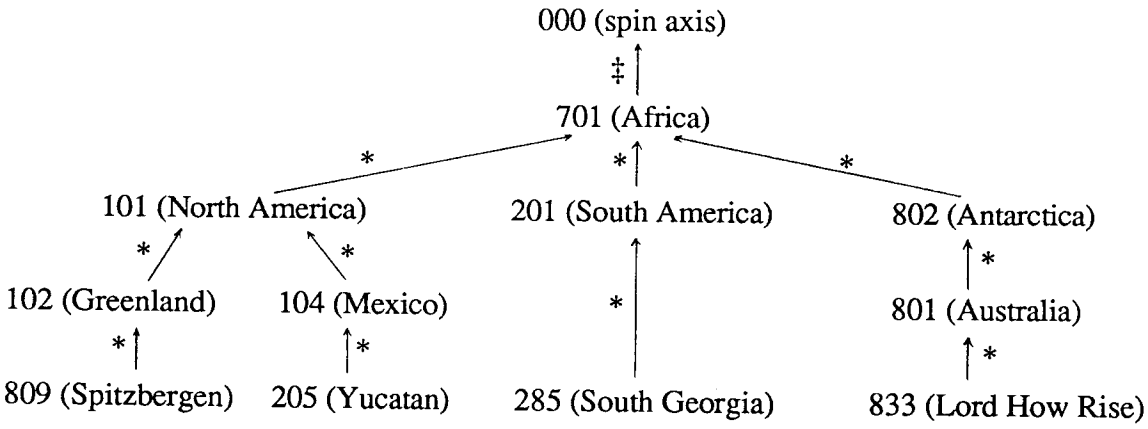
A rotation file contains a list of finite rotations between pairs of tectonic elements at different times and brief bibliographic notes or general comments for each individual rotation. Within POMP, rotation files are often created for reconstructions of specific times or regions. Such rotation files include MESO.ROT, PALEO.ROT, and SATL.ROT, for Mesozoic, Paleozoic, and South Atlantic reconstructions, respectively. On the following page is a sample segment, with column labels added, taken from a rotation file. PALEOMAP requires the seven column format shown; however, the file is read in a free format, so the spacing between each column does not matter.




```
201   0.0   0.00   0.00   0.00 701 !SAM-AFR
201   1.9  68.75 -41.47   0.62 701 !SAM-AFR  AN2
201  20.5  52.67 -31.64   7.71 701 !SAM-AFR  AN6
201  37.7  55.85 -32.83  14.32 701 !SAM-AFR  AN15
201  59.2  55.85 -32.83  21.62 701 !SAM-AFR  AN25
201  66.2  55.85 -32.83  24.96 701 !SAM-AFR  AN29
201  84.0  59.77 -35.40  33.13 701 !SAM-AFR  AN34
201 118.7  48.82 -32.90  52.34 701 !SAM-AFR  ANMO
201 138.0  45.50 -32.20  58.20 701 !SAM-AFR  FIT SCOTESE & LAWVER (1986)
201 245.0  45.50 -32.20  58.20 701 !SIMILAR TO RABINOWITZ & LABRECQUE (1979)
204 000.0   0.00   0.00   0.00 104 !HON-MEX
204  53.0 -39.70  87.90  15.10 104 !HON-MEX
204 127.0 -39.70  87.90  15.10 104 !HON-MEX
204 165.0 -39.70  87.90  31.10 104 !HON-MEX
204 245.0 -39.70  87.90  31.10 104 !SCOTESE ET AL (1979)
```

* Latitudes are positive to the North, longitudes are positive to the east

When PALEOMAP reads the rotation file, it first searchs for all the rotations corresponding to the given time of reconstruction. When there is no finite rotation for the given time, between a pair of tectonic elements, PALEOMAP interpolates the missing rotation from the two bracketing rotations (i.e. corresponding to the times immediately younger and immediately older than the given time). Since each finite rotation is defined relative to different reference plates (= tectonic element), the next step of the program is to restore each individual finite rotations between pairs of plates to a unique reference frame that is the earth spin axis. This requires the building of a consistent rotation file, i.e. that for each pair of tectonic elements, the reference tectonic element can be linked directly or indirectly to the spin axis, as in the following example:



* finite rotations describing relative motions

‡ finite rotations describing absolute motions
(i.e. relative to a hot-spot frame or to the geomagnetic axis)

In this example, each individual rotation can be calculated relative to Africa, and then added to the absolute motions of Africa relative to the spin axis. In case there is no rotation available for the absolute motions of the main reference plate, the user should add dummy rotations (ex.: 90°N, 0°E, angle=0°) in the rotation file, linking the main reference plate to the spin axis (000) at time 0 and 600Ma.

N.B.: Inconsistencies in a rotation file are a major source for runtime/error or incorrect plots.

MAP PARAMETERS

PALEOMAP can create paleocontinental base maps using a variety of map projections. PALEOMAP displays a map projection menu, from which the user selects the projection of the plot to be generated:

```
ENTER PROJECTION:
(1) MOLLEWEIDE
(2) MERCATOR
(3) ELLIPTICAL MERCATOR
(4) VAN DER GRINTEN
(5) STEREOGRAPHIC POLAR
(6) AZIMUTHAL EQUIDISTANT POLAR      (not yet available)
(7) ORTHOGRAPHIC
(8) RECTILINEAR
(9) TRANSVERSE MERCATOR
```

For selection 1, 2, 3, 4, 7 and 8, the next prompts ask for the latitudinal and longitudinal frame of the plot:

```
LATITUDINAL/LONGITUDINAL MAP FRAME
CONVENTIONS ARE +N,-S LATITUDE
                +E,-W LONGITUDE

ENTER NORTHERN LATITUDINAL BORDER
80                                   (input for 80°N)
ENTER SOUTHERN LATITUDINAL BORDER
-20                                  (input for 20°S)
ENTER EASTERN LONGITUDINAL BORDER
200                                  (input for 200°E)
ENTER WESTERN LONGITUDINAL BORDER
-20                                  (input for 20°W)
```

N.B.: the eastern longitude must be greater than the western longitude, e.g. the boundaries of a map from 160°E (westernmost longitude) to 160°W (easternmost longitude) should be entered as 200 [°E] (eastern longitudinal border) and 160 [°E] (western longitudinal border).

5 If the selected projection is 5 (Polar Stereographic) or Azimuthal Equidistant, the user is asked to select which hemisphere is to be plotted and to enter the plot's latitudinal extension, the maximum extension being the equator.

```
ENTER HEMISPHERE TO BE MAPPED
ENTER 1 FOR NORTHERN, 2 FOR SOUTHERN
1                                    (input)
PLEASE ENTER MINIMUM LATITUDE OF MAP
60                                   (input for 60°N)
```

9 Entries for option 9 (Transverse Mercator projections) depend on whether one of the geographic pole is wanted on the map or not:

```
ENTER LONGITUDE OF PRIME MERIDIAN
-40                                          (input for 40°W)
DO YOU INCLUDE ONE OF THE POLES ?
   1=NO   2=YES
1                                            (input for NO)
```

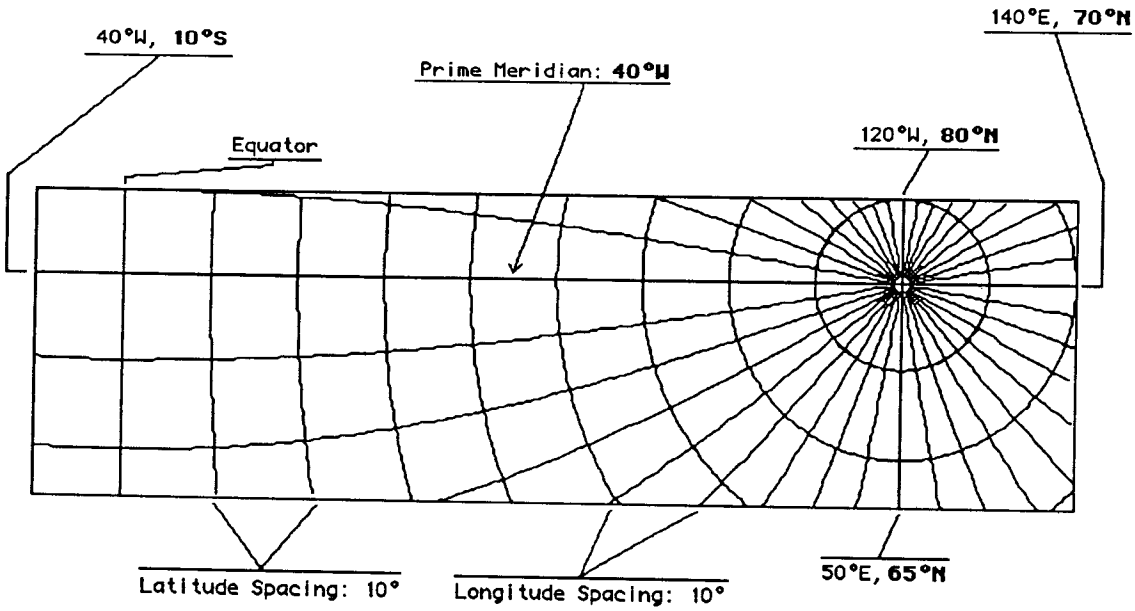
If the answer is no (1), the next entries are the latitudinal/longitudinal frame of the map, as for a regular Mercator projection (i.e. options.1, 2, 3, 4, 7 and 8).

```
2                                            (input for YES)
```

If a pole is to be included, the following prompts appear:

```
ENTER THE FIRST LATITUDE APPEARING ON THE PRIME MERIDIAN
-10                                          (input for 10°S)
      THE MINIMUM LATITUDE AT 180 DEGREES FROM THE PRIME MERIDIAN
70                                           (input for 70°N)
      THE MINIMUM LATITUDE AT +90 DEGREES FROM THE PRIME MERIDIAN
65                                           (input for 65°N)
      THE MINIMUM LATITUDE AT -90 DEGREES FROM THE PRIME MERIDIAN
80                                           (input for 80°N)
```

These parameters define a map including the north pole as illustrated below:



Scale of Map

The size of the map to be created and later plotted is determined directly by the PALEOMAP user.

```
ENTER LENGTH OF MAP IN INCHES
10                                          (input for 10 inches)
```

If the projection selected is Molleweide (1), Mercator (2), Elliptical Mercator (3), Van der Grinten (4), Orthographic (7) or Rectilinear (8), length refers to the distance in inches between the map's easternmost and westernmost longitude lines.

If the projection selected is Stereographic Polar (5) or Azimuthal Equidistant Polar (6), length is the distance value in inches of the plot's diameter or major axis.

For the Transverse Mercator maps (option 9), the user has to enter the scale in cm/degrees:

```
ENTER THE SCALE OF THE MAP (cm/degrees)
0.3                                         (input)
```

The overall dimensions of the plot will later be displayed in inches:

```
OVERALL SIZE OF YOUR PLOT:
        VERTICAL : 7.2  INCHES
      HORIZONTAL :11.5  INCHES
```

Grid Specifications

If a map grid is desired, the user can specify the distance, in degrees, between lines of latitude and longitude. These values have to be integer numbers:

```
ENTER THE DISTANCE IN DEGREES BETWEEN LINES OF LATITUDE
10                                          (input for a 10°lat. grid)
ENTER THE DISTANCE IN DEGREES BETWEEN LINES OF LONGITUDE
30                                          (input for a 30°long. grid)
```

The next entries correspond to the tickmarks around the frame. The tickmark spacing must be an integer:

```
ENTER SPACING FOR SMALL TICKMARKS (IN DEGREES)
2                                           (input for a ticmark every 2°)
ENTER SIZE OF SMALL TICKMARKS (IN DEGREES)
0.25                                        (input for a 0.25° size)
```

The size of the ticmarks is a function of the map scale and the projection. Also, size is doubled for every multiple of 5°.

If no grid and/or no tickmarks are desired, just enter 0 after these prompts .

DATA PLOTTING OPTIONS

Age Range of Data to be Plotted

The user may select an age range, determined by entering an oldest and youngest age in millions of years (Ma), of features to be plotted. When PALEOMAP searches the digitized data file, only those features whose ages fall whithin the specified range will be plotted.

```
DO YOU WISH TO ASSIGN AGE RANGE OF DATA TO PLOT?
   1=NO   2=YES
1                                          (input for NO)
```

If the answer is YES (2), then this prompt appears:

```
ENTER TIME RANGE OF DATA TO BE PLOTTED
ENTER: OLDEST, YOUNGEST
84.3 32.4                                  (input for the time range)
```

Only the data of which time of appearance is younger than 84.3 Ma and older than 32.4 Ma, will be plotted.

The default values are for the youngest limit the time of reconstruction entered in the beginning, and for the oldest limit 1,000 Ma.

N.B.: If time is 999 or 998, the youngest time limit is set to 0.

Modifying the Pen Assignments

Most versions of PALEOMAP allow the user to designate plotter pens according to a features's rotation ID number. For example, the user could assign pen number 3 to plot all 701 (African) features and pen number 2 to plot the 201 (South American) features. By using different colors for pens 2 and 3, a clear visual distintion is made between the two adjacent tectonic plates.

```
DO YOU WISH TO ASSIGN PEN COLOR BY ID#
   1=NO   2=YES
1                                          (input)
```

If the answer is yes (2), then this prompt appears:

```
ENTER ID# (1-1000) AND PEN NUMBER (1-4)
0 TO END
701 2                          (input for Africa and pen# 2)
201 3                          (input for S. America and pen# 3)
802 4                          (input for E. Antarctica and pen# 4)
0                              (input to end the list)
```

The default value for all tectonic elements is pen# 1.

Special Viewing and Plotting Options

PALEOMAP offers three viewing options, each of which is accomplished by a special rotation, and some plotting options to identify individual features on a map.

```
DO YOU WISH TO CHOOSE A SPECIAL VIEWING OR PLOTTING OPTION?
   1=NO    2=YES
1                                          (input for NO)
```

If the answer is YES (2), then the following prompts appear:

```
VIEWING OPTIONS: CHOOSE ONE
   (1) KEEP ONE CONTINENT FIXED IN PRESENT COORDINATES
   (2) CENTER VIEWING AREA ON SPECIFIC LAT,LONG PT.
   (3) ROTATE ENTIRE VIEWING AREA BY GLOBAL ROTATION
   (4) NO SPECIAL ROTATIONS
```

1 The menu's first option, *Keep One Continent Fixed in Present Coordinates*, allows the user to choose one of the tectonic elements to remain in its present day position. All other tectonic elements will be rotated relative to the fixed plate in accordance with the rotation file data [it is reminded that all the rotations are initially set relative to the spin axis (000), see paragraph concerning the rotation file]

```
ENTER NUMBER OF CONTINENT TO REMAIN FIXED
NA=101, SA=201, AFR=701, EUR=301, IND=501, AUS=801
801                                        (input for Australia)
DO YOU WISH TO PLOT LINES OF PALEOLATITUDE?
   1=NO    2=YES
1                                          (input for NO)
```

2 The second option, *Center Viewing Area on a Specific Lat/Long Point*, literally brings a specified coordinate to the center of the map produced. For example, if one wished to create a North Pacific plot using a Molleweide projection, centering the viewing area on the point 35,-180 would present an uninterrupted North Pacific expanse.

```
ENTER LAT,LONG OF POINT TO CENTER
-30 50                          (input for centering on 30°S, 50°E)
```

N.B.: This option has not been re-tested, problems may occur.

3 The third option, *Rotate Entire Viewing Area by Global Rotation,* rotates the entire globe around a pole of rotation specified by the user. The pole settings include latitude, longitude, and angle of opening. Subsequent to rotation, the viewing window boundaries will have coordinates different from those originally selected; the window dimensions, however, remain unchanged.

```
ENTER LAT, LONG AND ANGLE OF ROTATION
12.3 -34.5 22.27            (input for 12.3°N, 34.5°W, angle=22.27°)
```

N.B.: This option has not been re-tested, problems may occur.

4 By selecting the item *No Special Rotations.*, the user can choose a plotting option without having to select a special viewing option.

The plotting options available in PALEOMAP are generally used to identify individual features on a map according to the informations which appear in the two line headers at the beginning of each string of a data file. Aside from general illustrative purposes, such information can be very valuable when editing digitized data files. For comprehensive descriptions of the header items, see the User's Manuals concerning the digitizing software (POMP Progress Report # 37/1287) and the data management software (POMP Progress Report # 36/1287).

```
PLOTTING OPTIONS
   (1) PLOT STRING NUMBERS AT START OF LINE SEGMENT
   (2) PLOT ANOMALY / DATA ID NUMBER AT START OF LINE
   (3) PLOT PLATE ID NUMBER AT START OF LINE
   (4) NO EXTRA PLOT OPTIONS
```

1 String ID Numbers are plotted, no further entries needed

2 Numeric Descriptors (Anomaly/Data ID Number) are plotted

```
DO YOU WANT TO NUMBER FRACTURE ZONE SEGMENTS?
   1=NO   2=YES
2                                          (input for yes)
```

3 Rotation ID Numbers are plotted (at an appropriate scale) alongside their respective features, no further entries needed.

4 *No Extra Plot Options.* Similar in function to the No Special Options item, No Extra Plot Options allows the user to select a special viewing option and forgo a plotting option.

```
DO YOU WANT GRID MARKS ON THE CONTINENTS?
   1=YES    2=NO
```

Larger digitized land masses in the POMP data base have grid marks spaced at 5° latitude and longitude intervals. The marks form a cross, the orientation of which indicates present North, South, East, and West. Should the user choose this option, these grid marks may be excluded from the plot.

```
DO YOU WANT THE TIME OF RECONSTRUCTION IN THE CORNER OF THE MAP
   1=NO    2=YES
```

The time of reconstruction will appear on the map.

DATA FILES

The last, but not the least, entries are the data file names:

```
ENTER THE NAME OF THE FILE TO BE PLOTTED
  (TYPE QUIT TO END THE PROGRAM)
SOUTH_ATL.DAT                                    (input)
ENTER THE NAME OF THE FILE TO BE PLOTTED
  (TYPE QUIT TO END THE PROGRAM)
ISOCHRON.DAT                                     (input)
ENTER THE NAME OF THE FILE TO BE PLOTTED
  (TYPE QUIT TO END THE PROGRAM)
QUIT                                             (input)
```

OUTPUT FILE

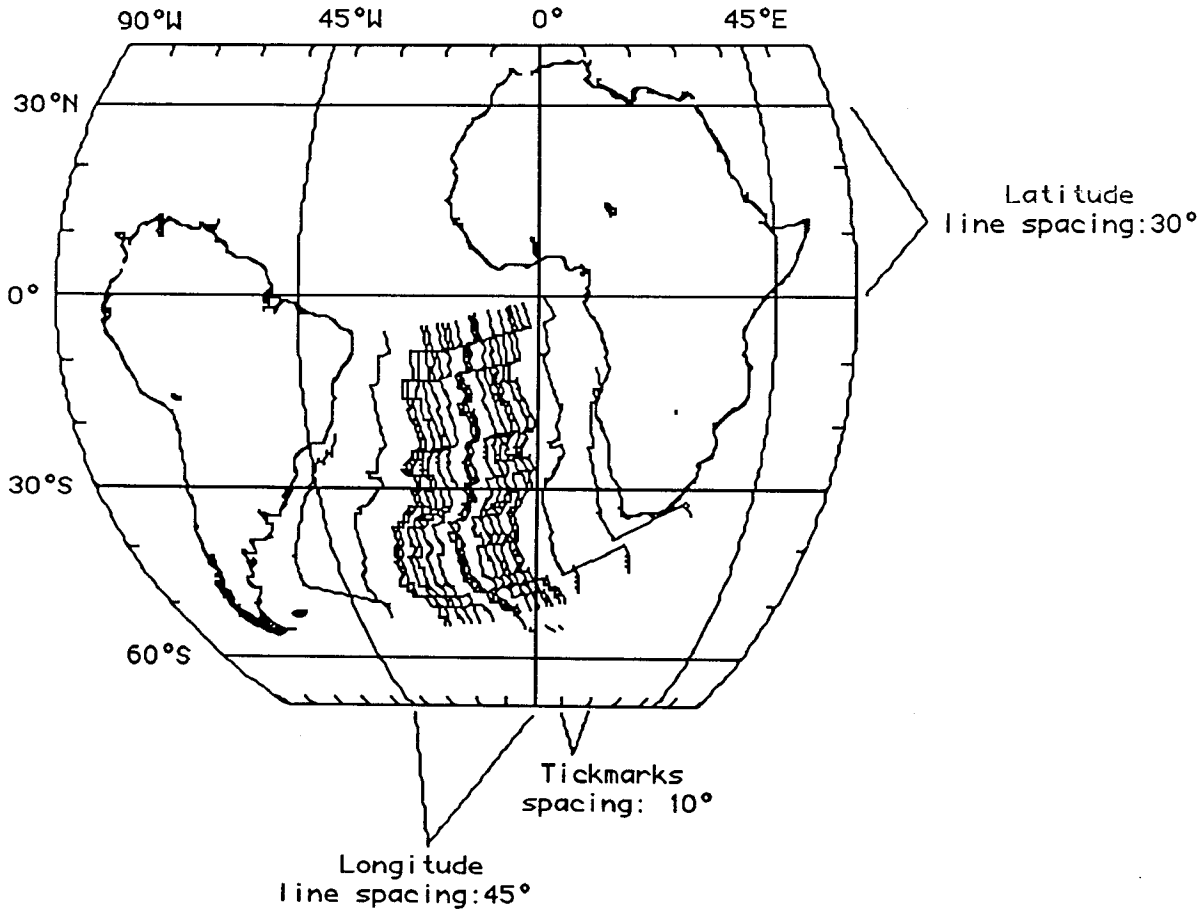
The VAX version of PALEOMAP produces a FOR095.DAT file that can later be sent to a plotting device.

The Macintosh version of PALEOMAP allows the user to select the plotting device (the screen for example) where the plot will be generated interactively, or to create an output file that can later be sent to a plotting device.

Molleweide Projection

Inputs:

0	Time of reconstruction: ----------present-day
1	Molleweide projection
40	Northern Latitudinal Border: ---------- 40°N
-70	Southern Latitudinal Border:---------- 70°S
60	Eastern Longitudinal Border: ---------- 60°E
-90	Western Longitudinal Border: ---------- 90°W
(6)	*(Original size of the map in inches)*
30	Latitude line spacing ---------- every 30°
45	Longitude line spacing---------- every 45°
10	Tickmark spacing---------- every 10°
1	Tickmark size---------- 1°
1	No change in the time range:---------- 0 to 1000 Ma
1	No pen change
1	No special option
TEST.DAT	Data file
QUIT	End of program.

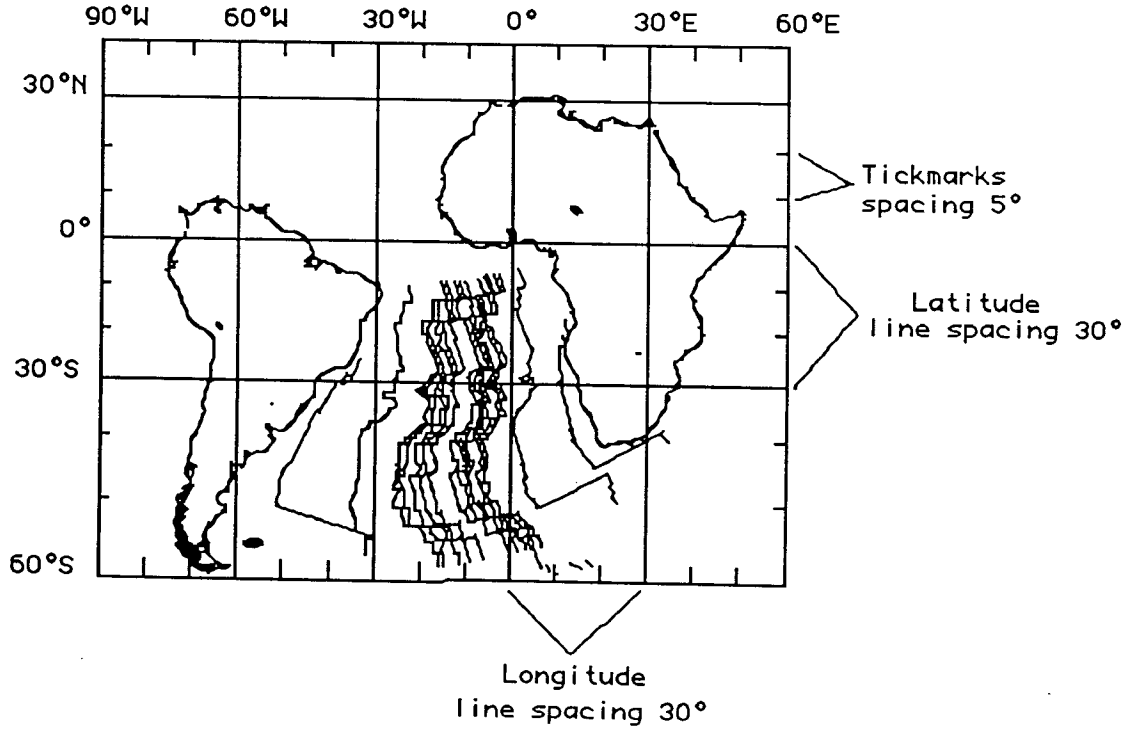


Elliptical Mercator Projection

Inputs:

20	Time of reconstruction: ---------- 20 Ma
TEST.ROT	Rotation file
3	Elliptical Mercator projection
40	Northern Latitudinal Border: ---------- 40°N
-60	Southern Latitudinal Border: ---------- 60°S
60	Eastern Longitudinal Border: ---------- 60°E
-90	Western Longitudinal Border: ---------- 90°W
(6)	*(Original size of the map in inches)*
30	Latitude line spacing ---------- every 30°
45	Longitude line spacing ---------- every 45°
5	Tickmark spacing ---------- every 5°
1	Tickmark size ---------- 1°
1	No change in the time range: ---------- 20 to 1000 Ma
1	No pen change
1	No special option
TEST.DAT	Data file
QUIT	End of program.

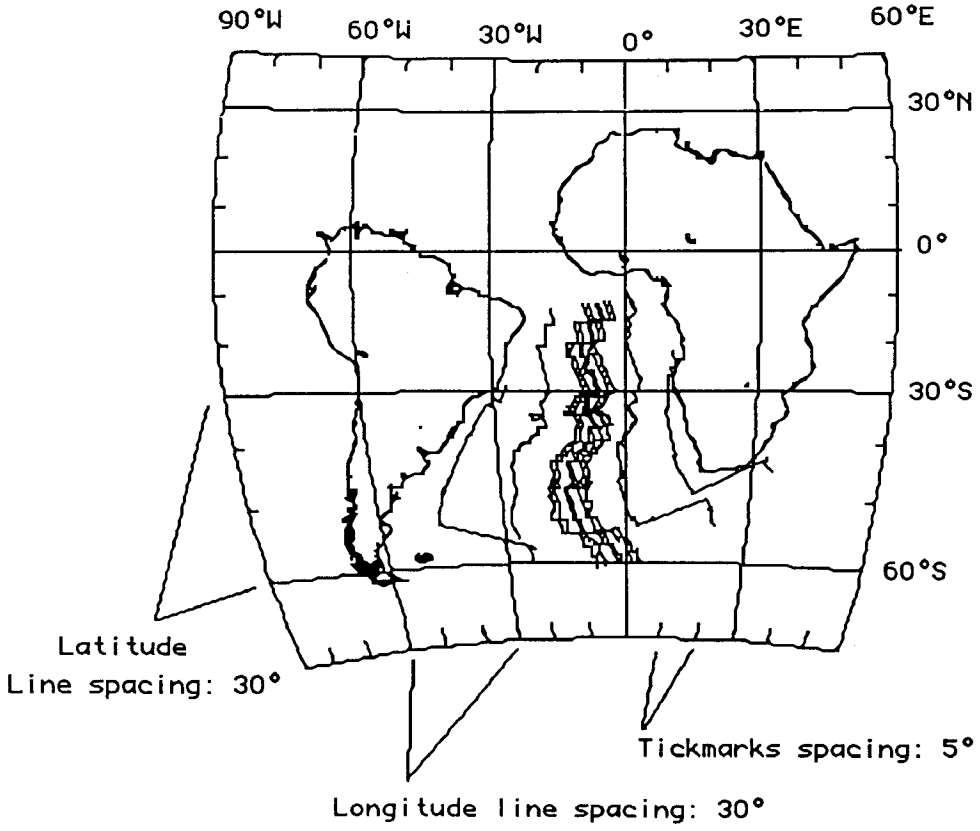
N.B.: The same map in a straight Mercator projection or rectilinear projection would have been very similar to this one. Except in line 3, the inputs would have been identical.



Van Der Grinten Projection

Inputs:

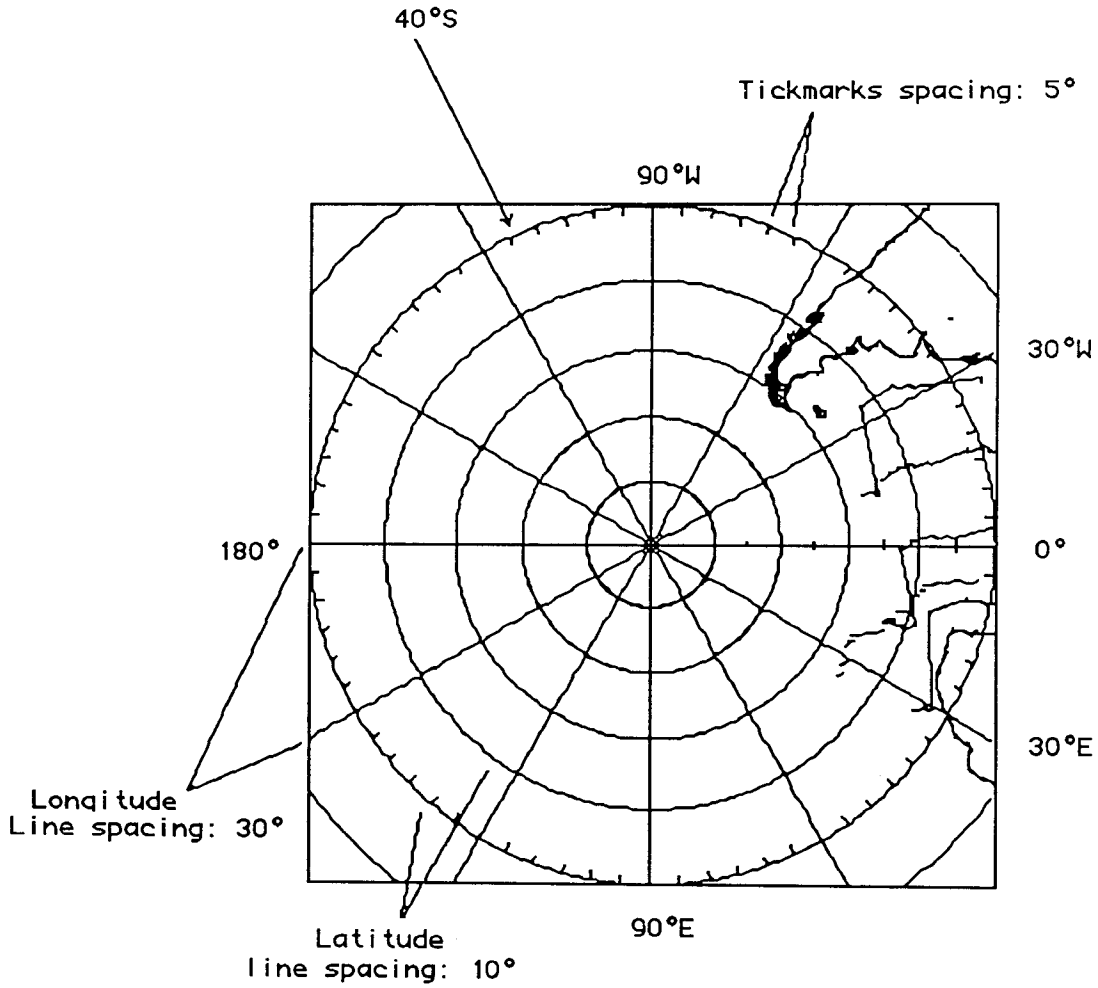
40	Time of reconstruction: ---------- 40 Ma
TEST.ROT	Rotation file
3	Elliptical Mercator projection
40	Northern Latitudinal Border: ---------- 40°N
-70	Southern Latitudinal Border: ---------- 70°S
60	Eastern Longitudinal Border: ---------- 60°E
-90	Western Longitudinal Border: ---------- 90°W
(6)	*(Original size of the map in inches)*
30	Latitude line spacing ---------- every 30°
30	Longitude line spacing ---------- every 30°
5	Tickmark spacing ---------- every 5°
1	Tickmark size ---------- 1°
1	No change in the time range: ---------- 40 to 1000 Ma
1	No pen change
1	No special option
TEST.DAT	Data file
QUIT	End of program.



Stereographic Polar Projection

Inputs:

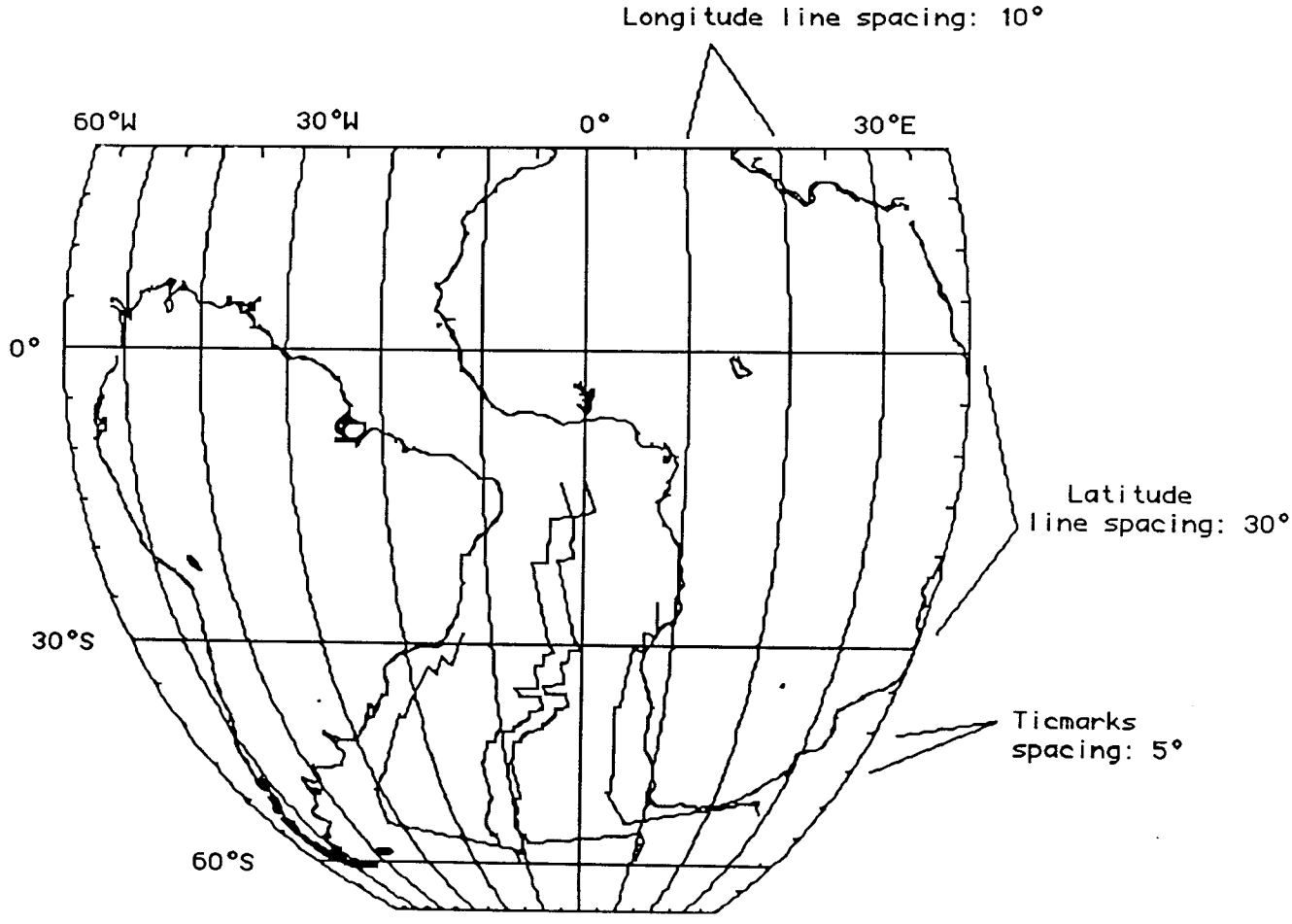
60	Time of reconstruction: ---------- 60 Ma
TEST.ROT	Rotation file
5	Stereographic Polar projection
2	Southern Hemisphere
40	Minimum Latitude of the map: ---------- 40°S
(6)	*(Original size of the map in inches)*
10	Latitude line spacing ---------- every 10°
30	Longitude line spacing---------- every 30°
5	Tickmark spacing---------- every 5°
0.5	Tickmark size ---------- 0.5°
1	No change in the time range:---------- 60 to 1000 Ma
1	No pen change
1	No special option
TEST.DAT	Data file
QUIT	End of program.



Orthographic Projection

Inputs:

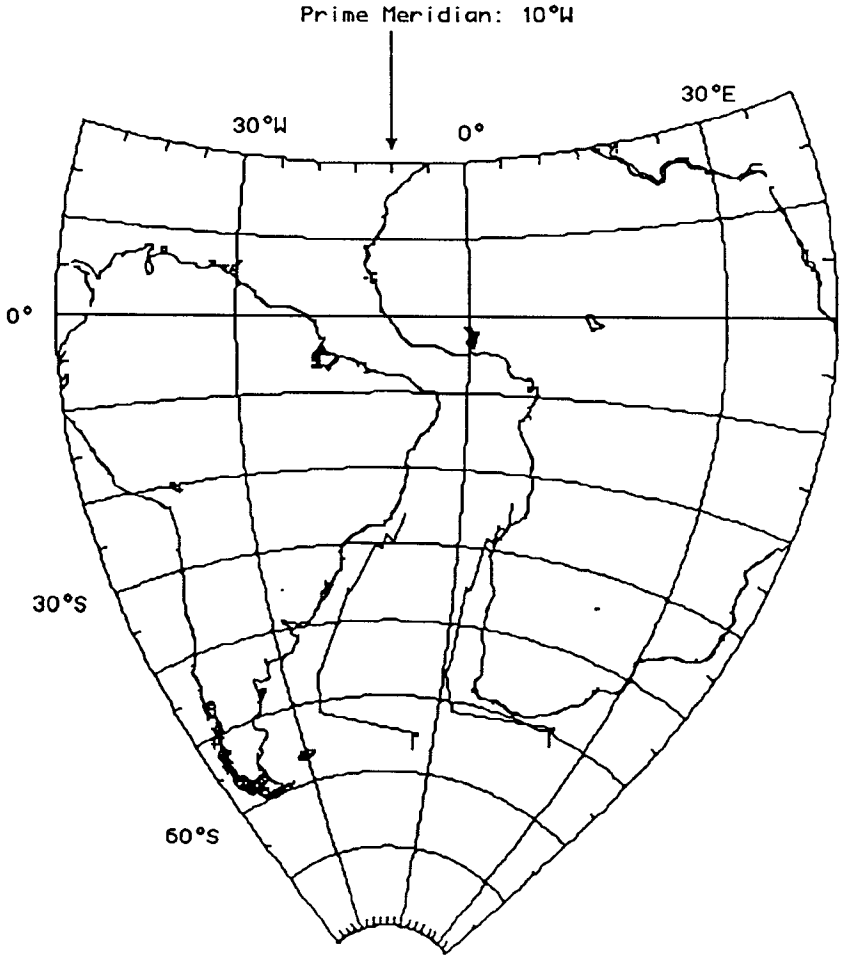
80	Time of reconstruction: ---------- 80 Ma
TEST.ROT	Rotation file
7	Orthographic projection
20	Northern Latitudinal Border: ---------- 20°N
-70	Southern Latitudinal Border: ---------- 70°S
40	Eastern Longitudinal Border: ---------- 40°E
-60	Western Longitudinal Border: ---------- 60°W
(6)	*(Original size of the map in inches)*
30	Latitude line spacing ---------- every 30°
10	Longitude line spacing ---------- every 10°
5	Tickmark spacing ---------- every 5°
0.5	Tickmark size ---------- 0.5°
1	No change in the time range: ---------- 80 to 1000 Ma
1	No pen change
1	No special option
TEST.DAT	Data file
QUIT	End of program.



Transverse Mercator Projection (without pole)

Inputs:

90	Time of reconstruction: ---------- 90 Ma
TEST.ROT	Rotation file
9	Transverse Mercator projection
-10	Prime Meridian: ---------- 10°W
1	No geographic pole included
20	Northern Latitudinal Border: ---------- 20°N
-80	Southern Latitudinal Border: ---------- 80°S
40	Eastern Longitudinal Border: ---------- 40°E
-50	Western Longitudinal Border: ---------- 50°W
(0.2)	*(Original scale of the map in cm/degree of longitude)*
10	Latitude line spacing ---------- every 10°
30	Longitude line spacing ---------- every 30°
5	Tickmark spacing ---------- every 5°
0.5	Tickmark size ---------- 0.5°
1	No change in the time range: ---------- 90 to 1000 Ma
1	No pen change
1	No special option
TEST.DAT	Data file
QUIT	End of program.



Transverse Mercator Projection (including a pole)

Inputs:

100	Time of reconstruction: ---------- 100 Ma
TEST.ROT	Rotation file
9	Transverse Mercator projection
-20	Prime Meridian (PM): ---------- 20°W
2	Geographic pole included
20	First Latitude on PM: ---------- 20°N
-80	Minimum Latitude at 180° from PM:------- 80°S at 160°E
-40	Minimum Latitude at 90° from PM: --------- 40°S at 70°E
-50	Minimum Latitude at 270° from PM:------ 50°S at 110°W
(0.15)	*(Original scale of the map in cm/degree of longitude)*
10	Latitude line spacing ---------- every 10°
30	Longitude line spacing---------- every 30°
0	No tickmark
1	No change in the time range:---------- 100 to 1000 Ma
1	No pen change
1	No special option
TEST.DAT	Data file
QUIT	End of program.